

TITLE: Towards Simulating a Realistic Planetary Seismic Wavefield: The Contribution of the Megaregolith and Low-Velocity Waveguides

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Lunar seismograms are distinctly different from their terrestrial counterparts. The Apollo lunar seismometers recorded moonquakes without distinct P- or S-wave arrivals; instead waves arrive as a diffuse coda that decays over several hours making the identification of body waves difficult. The unusual character of the lunar seismic wavefield is generally tied to properties of the megaregolith: it consists of highly fractured and broken crustal rock, the result of extensive bombardment of the Moon. The megaregolith extends several kilometers into the lunar crust, possibly into the mantle in some regions, and is covered by a thin coating of fine-scale dust. These materials possess very low seismic velocities that strongly scatter the seismic wavefield at high frequencies. Directly modeling the effects of the megaregolith to simulate an accurate lunar seismic wavefield is a challenging computational problem, owing to the inherent 3-D nature of the problem and the high frequencies (>1 Hz) required.

Here we focus on modeling the long duration coda, studying the effects of the low velocities found in the megaregolith. We produce synthetic seismograms using 1-D slowness integration methodologies, GEMINI and reflectivity, and a 3-D Cartesian finite difference code, Wave Propagation Program, to study the effect of thin layers of low velocity on the surface of a planet. These codes allow us generate seismograms with dominant frequencies of ~ 1 Hz. For background lunar seismic structure we explore several models, including the recent model of Weber et al., Science, 2011. We also investigate variations in megaregolithic thickness, velocity, attenuation, and seismogram frequency content.

Our results are compared to the Apollo seismic dataset, using both a cross correlation technique and integrated envelope approach to investigate coda decay. We find our new high frequency results strongly support the hypothesis that the long duration of the lunar seismic codas is generated by the presence of the low velocity megaregolith, and that the diffuse arrivals are a combination of scattered energy and multiple reverberations within this layer. The 3-D modeling indicates the extreme surface topography of the Moon adds only a small contribution to scattering effects, though local geology may play a larger role. We also study the effects of the megaregolith on core reflected and converted phases and other body waves. Our analysis indicates detection of core interacting arrivals with a

polarization filter technique is robust and lends the possibility of detecting other body waves from the Moon.

These predictive techniques are powerful tools for understanding the character of a planetary seismic wavefield. Modeling the effects of subsurface oceans, impact modified surfaces, and other highly fractured materials will provide advance details, such as frequency content and sensitivity, shadow zones, and other useful constraints for designing science goals for instrumentation deployed in new missions.